

Defender: A High-Yielding, Processing Potato Cultivar with Foliar and Tuber Resistance to Late Blight

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ABSTRACT

The potato cultivar Defender is high-yielding, white-skinned, and notable for having foliar and tuber resistance to late blight infection caused by *Phytophthora infestans* (Mont.) de Bary. It was released in 2004 by the USDA-ARS and the agricultural experiment stations of Idaho, Oregon, and Washington. Defender is suitable for processing into french fries and other frozen potato products directly from the field or from storage. Defender also may be used for fresh markets in regions such as California, where cultivars with long tubers and white skin are traditionally grown. Resistances to late blight and other potato diseases make Defender an ideal candidate for organic potato production. Defender consistently produced greater total and U.S. No. 1 yields than 'Russet Burbank' in Idaho trials. In early harvest trials conducted in the western U.S., average total yields of Defender were 17% and 23% greater than yields for 'Ranger Russet' and 'Shepody', respectively. In full-season trials conducted in the western U.S., Defender averaged 10% and 15% higher yields than Ranger Russet and

Russet Burbank, respectively. Specific gravity of Defender is consistently high, with values comparable to those of Ranger Russet; tuber ascorbic acid (Vitamin C) levels are also high. In addition to late blight, Defender also is resistant to tuber early blight (*Alternaria solani*, (Ellis & G. Martin), L.R. Jones & Grout), potato virus X, and net necrosis; it has moderate levels of resistance to Verticillium wilt (*Verticillium dahliae*, Kleb), pink rot, foliar early blight, corky ringspot, and Erwinia soft rot. Defender is susceptible to scab (common and powdery) and potato leafroll virus; it has moderate susceptibility to dry rot (*Fusarium* spp.) and potato virus Y. Susceptibilities to internal necrosis, tuber greening, and blackspot bruise also have been noted, but may be minimized through cultural and harvest practices.

RESUMEN

Defender es un cultivar de papa de alto rendimiento, piel blanca y excelente por su resistencia al tizón tardío causado por *Phytophthora infestans* (Mont.) de Bary, tanto a la infección foliar como a la de los tubérculos. Ha sido liberada el 2004 por USDA-ARS y las Estaciones Experimentales Agrícolas de Idaho, Oregon y Washington. Defender es apropiado para el procesamiento de papa frita y otros productos congelados de papa, direc-

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tamente del campo o del almacén. Defender puede también ser usado en regiones como California, donde se cultivan tradicionalmente variedades de tubérculos alargados y piel blanca. La resistencia al tizón tardío y otras enfermedades de la papa hace de Defender un candidato ideal para la producción orgánica. Defender tuvo consistentemente un mayor rendimiento de tubérculos de grado "US No. 1" que Russet Burbank en pruebas en Idaho. En ensayos de cosecha temprana realizados en el oeste de EUA, el promedio de rendimiento total de Defender fue de 17 y 23% mayor que el de las variedades Ranger Russet y Shepody respectivamente. En ensayos de ciclo completo realizadas en el oeste, Defender tuvo rendimientos 10 y 15% mayores que Ranger Russet y Russet Burbank respectivamente. El peso específico de Defender es consistentemente alto, con valores comparables a los de Ranger Russet y los niveles de ácido ascórbico (Vitamina C) son también altos. Además de ser resistente al tizón tardío, Defender es también resistente al tizón temprano (*Alternaria solani* (Ellis & G. Martín) L. R. Jones & Grout), Virus X de la papa y necrosis en red. Tiene niveles moderados de resistencia a marchitez por *Verticillium* (*Verticillium dahliae* Kleb.), pudrición rosada, tizón foliar temprano, mancha corchosa en anillo y pudrición blanda causada por *Erwinia*. Defender es susceptible a la sarna (común y polvorienta) y al virus del enrollamiento; tiene moder-

ada susceptibilidad a la pudrición seca (*Fusarium* spp.) y al virus Y de la papa. También se ha notado susceptibilidad a necrosis interna, verdeamiento del tubérculo y mancha negra, pero estas pueden minimizarse a través de prácticas culturales.

INTRODUCTION

Defender was first grown and selected in the field at Aberdeen, ID, in 1993 where it was given the clonal designation A90586-11. It originated from a hybridization by J. J. Pavék in 1990 between breeding clone KSA195-90 and Ranger Russet. KSA195-90 was a selection made at Aberdeen, ID, from true potato seed received from the Polish Plant Breeding and Acclimatization Institute, Radzików, Poland. KSA195-90 initially was used in the Aberdeen Potato Breeding Program as a source of resistances to potato viruses S, X, Y and potato leafroll virus (PLRV). Subsequently, it and other selections with Polish germplasm in the ancestry were identified as sources of resistance to the aggressive, metalaxyl-resistant genotypes of *Phytophthora infestans* that were identified in the USA in the early 1990s (Corsini et al. 1999). The original source of late blight resistance found in KSA195-90 is unclear in that a diverse number of Mexican and South American wild and cultivated species are in its background. Corsini et al. (1999) speculated that this diversity may contribute to durable resistance, although R-genes from *Solanum demissum* are

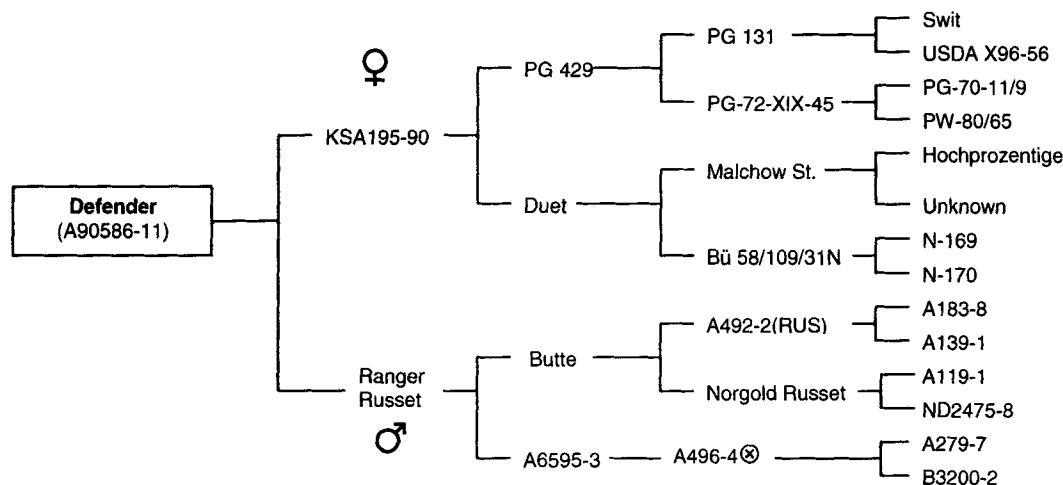


FIGURE 1.
Pedigree of Defender.

likely present as well. Potato cultivars in the pedigree of Defender (Figure 1) include the North American cultivars Butte (Pavek et al. 1978), and Norgold Russet (Johansen 1965), as well as the European cultivars Duet, Malchow St., Swit, and Hochprozentige.

Defender was evaluated as a 12-hill selection in 1994, and from 1995 through 1998 in replicated yield trials in Idaho. Defender was entered in Tri-State trials in Idaho, Oregon, and Washington in 1999, and subsequently advanced to the Western Regional Potato Variety Trials where it was evaluated at sites in California, Colorado, Idaho, New Mexico, Oregon, Texas, and Washington in 2000 through 2002. Subsequent seed increases and commercial trials of Defender were conducted in Idaho, Oregon, and Washington.

On the basis of its late blight resistance and agronomic performance in research and commercial trials, the decision

was made by the Northwest (Tri-State) Potato Variety Development Program Committee to release A90586-11 as Defender. The name Defender refers to its foliar and tuber resistances to *Phytophthora infestans* that “defend” against late blight. Release documents were completed in 2004.

VARIETAL DESCRIPTION

Plant and tuber descriptions of Defender were obtained from field evaluations conducted at Aberdeen, ID, unless noted otherwise.

Plants (Figure 2A)

Growth habit: Large, semi-erect vine with late maturity (approximately 1 to 2 weeks later than Russet Burbank).

Tubers of Defender bulk quickly and its late vine maturity can be misleading with respect to actual

tuber size and yield. *Stems:* Green, with no or weakly expressed anthocyanin pigmentation and straight-edged stem wings. *Leaves* (Figure 2B): Yellow-green, moderately pubescent with a medium-open silhouette; petiole pigmentation is absent. *Terminal leaflets:* Medium ovate, with acuminate tip, cordate base, and wavy margins; average length of 74 mm, width of 50 mm (160 leaves). *Primary leaflets:* Range of three to six pairs, with an average of 4.4; medium ovate with an acuminate tip and cordate base. *Secondary leaflets:* Range of one to eight pairs, average of 4.0. *Tertiary leaflets:* Range of 0 to 14 pairs, average of 6.0. *Stipules:* Medium, semi-clasping.

Flowers (Figure 2B)

Range of one to seven inflorescences per plant, average of 3.5, with a range of 1 to 13 buds/inflorescence; no pigmentation of calyx. *Corolla:* White, pentagonal. *Anthers:* Yellow (Value 17A, Royal

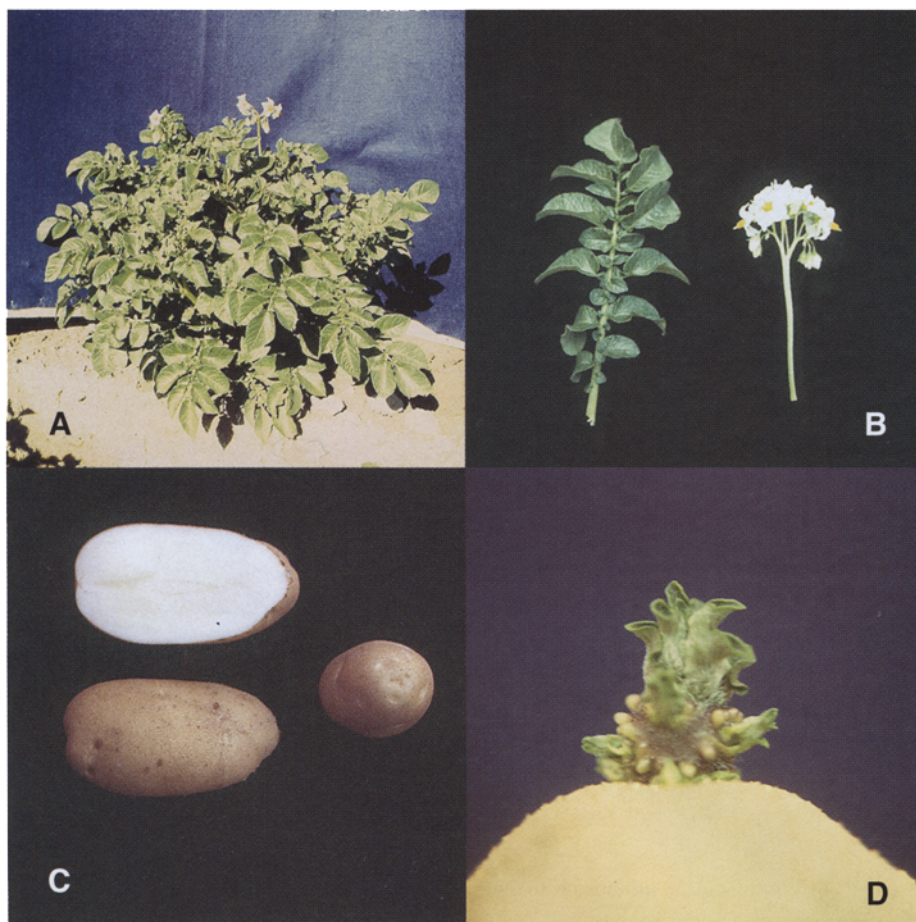


FIGURE 2. Defender: (A) plant, (B) leaf and inflorescence, (C) tuber and flesh, and (D) light sprout.

Horticultural Society Color Chart, London), broad cone-shaped, with limited shed of pollen-considered male-sterile; successfully used as a female parent in sexual hybridizations. *Stigma*: Capitate. *Berries*: None or low numbers generally found in the field.

Tubers (Figure 2C)

Long; width and thickness comparable to Russet Burbank, but an average of 12 mm shorter than Russet Burbank (160 tubers, 200 to 250 g); mean length: 119 mm (range 67 to 159), mean width: 65 mm (range of 53 to 81), mean thickness: 57 (range 45 to 70). *Set*: Low-medium (five to eight / hill). *Skin*: White to buff. *Eyes*: Shallow to intermediate depth, with a mean number of 16.7 eyes per tuber evenly distributed along the tuber; eyebrows are slightly prominent. *Flesh*: White. *Dormancy*: In storage trials conducted over 2 years with no sprout inhibitors applied, Defender had a dormancy of 108 days following storage at 7.2 C, as compared with Russet Burbank at 158 days (Kleinkopf et al. 2004, 2005). Duration of dormancy was defined as the number of days from harvest until 80% of potatoes had at least one sprout ≥ 5 mm in length.

Light Sprouts (Figure 2D)

Broad, green, no pigmentation, pubescent.

AGRONOMIC PERFORMANCE

Defender is a high-yielding cultivar, surpassing Ranger Russet and Russet Burbank in total yield by 1.2 and 11.5 mt/ha, respectively, in full-season trials in central and eastern Idaho (Table 1). U.S. No. 1 grade (76%) was intermediate between

that of Ranger Russet (84%) and Russet Burbank (64%). Tuber size of Defender is greater than that of Russet Burbank, with 14% more tubers in the oversize class (>341 g) and 4% less in the undersize category (<114 g). However, relative to Ranger Russet, tuber size is smaller, with 6% less in the 170 to 341 g size category, and 4% more tubers < 114 g.

Defender also was evaluated in the 2000-2002 Western Regional Potato Variety Trials. Defender yields were notably high in both the early-harvest and full-season trials relative to check cultivars (Tables 2 and 3). Percentage of U.S. No. 1 yield was comparable to Ranger Russet and significantly higher than that of Russet Burbank in both early and full-season trials.

TUBER QUALITY CHARACTERISTICS AND USAGE

Fry Characteristics

French fry color of Defender from tubers grown in full-season trials was slightly darker than that of Ranger Russet and Russet Burbank after extended storage at 4.4 or 7.2 C (Tables 1 and 3). The fry color of Defender at early-harvest sites in the 2000-2002 Western Regional Potato Variety Trials was consistent with values observed for Ranger Russet and Shepody, indicative of its potential as an early processing cultivar (Table 2). Defender fry color was consistently acceptable following long-term storage of tubers obtained from trials conducted in Washington, Idaho, and Oregon (Table 4). Uniformity of fry color from stem to bud end also was acceptable following long-term storage with the exception of tubers from Oregon (Table 4). On average, reducing sugar concentrations in tubers of Defender were comparable to those of Ranger

TABLE 1—Average total yield, U.S. No. 1 yield, percentage of U.S. No. 1, specific gravity, tuber size distribution, and french fry color of Defender, Ranger Russet, and Russet Burbank from 16 full-season yield trials (135 to 150 days) in central and eastern Idaho¹.

Cultivar	Yield (mt/ha)			Specific Gravity ²	Tuber Size Distribution as Percent of Total Yield					Fry color ³	
	Total	U.S. No. 1	% No. 1		>341 g	341 g	170-169 g	114- <114 g	Cull	4.4 C	7.2 C
Defender	55.6	42.9	76	1.092	29	36	11	10	14	3.3	1.5
Ranger Russet	54.4	45.7	84	1.089	31	42	12	6	10	3.2	1.4
Russet Burbank	44.1	28.4	64	1.079	15	34	15	14	22	3.1	1.3

¹Trials were conducted from 1996 to 2003 and included the following Idaho locations with their respective number of trials: Aberdeen (10), Kimberly (4), Rexburg (1), and Shelley (1).

²Specific gravities were determined using the weight-in-air, weight-in-water method.

³French fry scores rated using USDA standards, with 0 = light and 4 = dark. A rating of ≤ 2.0 is an acceptable score. Tubers were evaluated following 3 to 6 months storage at 4.4 or 7.2 C.

TABLE 2—Total yield, percent U.S. No. 1, specific gravity, and field fry color of Defender, Ranger Russet, and Shepody in early harvest trials in the 2000 to 2002 Western Regional Potato Variety Trials¹.

	CA ²	OR		TX	WA	Mean	
		1	2			All Sites	CA Excluded
<i>Total Yield (mt/ha)</i>							
Defender	43.8	72.4	51.3	39.2	53.1	51.7	54.3
Ranger Russet	38.3	59.2	46.3	32.9	49.5	44.2	46.1
Shepody	n.a.	57.6	46.9	25.3	46.3	n.a.	44.0
<i>% U.S. No. 1</i>							
Defender	94	80	66	71	71	78	72
Ranger Russet	94	82	61	62	76	75	70
Shepody	n.a.	79	56	55	72	n.a.	66
<i>Specific Gravity</i>							
Defender	1.086	1.074	1.092	1.077	1.075	1.081	1.080
Ranger Russet	1.084	1.070	1.089	1.067	1.073	1.077	1.075
Shepody	n.a.	1.069	1.082	1.067	1.071	n.a.	1.072
<i>Field Fry Color³</i>							
Defender	n.a.	0.17	0.20	n.a.	0.0	0.12	n.a.
Ranger Russet	n.a.	0.10	0.03	n.a.	0.0	0.04	n.a.
Shepody	n.a.	0.00	0.33	n.a.	0.0	0.11	n.a.

¹Trial locations were Kern County (CA), Hermiston (OR-1), Malheur (OR-2), Springlake (TX), and Pasco (WA).

²Means of 2000 and 2002 trials; Defender was not included in the 2001 trial.

³French fry scores rated using USDA standards, with 0 = light and 4 = dark. A rating of ≤ 2.0 is an acceptable score.

Russet and Russet Burbank. Defender showed earlier dormancy break than Ranger Russet and Russet Burbank based on greater sprout length (Table 4). Over a 3-year period, the post-harvest, process rating of Defender (rating comprised of fry color, reducing sugar concentrations, tuber specific gravity, and sensory evaluations) was intermediate to values observed for the processing cultivars Ranger Russet and Russet Burbank indicative of its value as a processing cultivar (Table 5).

Specific Gravity

The mean specific gravities of Defender in full-season trials in Idaho and other western sites were ≥ 1.090 —consistently greater than gravities observed for Ranger Russet or Russet Burbank (Tables 1 and 3). At early harvest sites in the Western Regional

TABLE 3—Total yield, percent U.S. No. 1, specific gravity, and fry color of Defender, Ranger Russet and Russet Burbank in full-season trials in the 2000 to 2002 Western Regional Potato Variety Trials¹.

	CA	CO ²	ID		NM	OR			WA	Mean
			1	2		1	2	3		
<i>Total Yield (mt/ha)</i>										
Defender	62.2	63.8	60.9	60.2	61.2	106.9	69.3	53.4	95.2	70.3
Ranger Russet	58.9	51.7	54.8	59.8	59.1	97.8	58.2	52.8	83.9	64.1
Russet Burbank	59.8	54.5	55.0	55.4	45.7	87.7	58.1	54.7	79.7	61.2
<i>% U.S. No. 1</i>										
Defender	81	74	68	62	90	83	76	77	70	76
Ranger Russet	79	84	75	64	87	75	72	74	75	76
Russet Burbank	72	71	60	43	65	62	65	49	62	61
<i>Specific Gravity</i>										
Defender	1.088	1.102	1.088	1.085	1.096	1.079	1.088	1.098	1.086	1.090
Ranger Russet	1.085	1.085	1.087	1.082	1.090	1.078	1.087	1.098	1.087	1.087
Russet Burbank	1.086	1.088	1.080	1.079	1.080	1.077	1.085	1.078	1.083	1.082
<i>Fry Color³</i>										
Defender	n.a.	2.0	1.4	1.6	n.a.	1.4	n.a.	0.8	3.3	1.8
Ranger Russet	n.a.	1.5	1.3	1.4	n.a.	0.9	n.a.	0.2	2.7	1.3
Russet Burbank	n.a.	1.0	1.1	1.2	n.a.	1.2	n.a.	1.5	3.0	1.5

¹Trial locations were Tulelake (CA), San Luis Valley (CO), Aberdeen (ID-1), Kimberly (ID-2), Farmington (NM), Hermiston (OR-1), Klamath Falls (OR-2), Ontario (OR-3), and Othello (WA).

²Means of 2001 and 2002 trials; Defender was not included in the 2000 trial.

³French fry scores rated using USDA standards, with 0 = light and 4 = dark. A rating of ≤ 2.0 is an acceptable score. Tubers were evaluated following 6 to 11 weeks storage at 7.2 C, with the exception of WA with storage at 6.7 C.

TABLE 4—Post-harvest ratings of Defender, Ranger Russet, and Russet Burbank following 7 months of storage (3 months at 8.9 C and 4 months at 6.7 C). All post-harvest evaluations and ratings were conducted at Pullman, WA, in 2000 to 2002 using tubers from trials at Aberdeen, ID, Hermiston, OR, and Warden/Othello, WA.

Clone	Photovolt Reading ¹			Difference ² : Stem vs. Bud	USDA Color Rating ³	% Reducing Sugars ⁴			Sprouting	
	Stem	Bud	Avg.			Stem	Bud	Avg.	% of Tubers	Sprout Length (mm)
Washington										
Defender	26.3	28.9	27.6	6.9	1.0	1.3	0.9	1.1	100	86
Ranger Russet	21.6	30.2	25.9	10.9	2.0	1.8	1.0	1.4	100	127
Russet Burbank	29.6	35.5	32.5	8.5	0.7	1.0	0.7	0.9	66.7	15
Idaho										
Defender	28.2	34.4	31.3	8.6	1.0	1.0	0.6	0.8	100	127
Ranger Russet	30.7	41.9	36.3	11.5	0.3	1.2	0.4	0.8	100	74
Russet Burbank	31.2	41.0	36.1	11.7	0.7	1.0	0.4	0.7	100	15
Oregon										
Defender	21.4	33.0	27.2	13.2	2.0	1.7	0.7	1.1	100	175
Ranger Russet	22.2	34	28.1	13.1	2.0	2.0	0.9	1.4	100	37
Russet Burbank	25.3	40.2	32.8	15.2	1.3	1.4	0.4	0.9	100	20

¹Fries (0.95 cm x 2.87 cm) were fried at 191 C for 3.5 minutes and color was measured with a Photovolt meter within 3 min of removal from oil. A Photovolt reading of ≤19 is considered unacceptably dark (see footnote 3 below).

²A difference of ≥9 Photovolt units between bud and stem end constitutes non-uniform fry color. Values represent an average of actual Photovolt differences in each of three years and therefore do not relate directly to averaged stem and bud values listed in the table.

³USDA color (0 = light and 4 = dark) ratings were assigned based upon photovolt readings of the darkest ends of fries (typically stem ends); Photovolt readings (≥31 = USDA 0, 25-30 = USDA 1, 20-24 = USDA 2, 15-19 = USDA 3, ≤14 = USDA 4).

⁴Dry matter basis

TABLE 5—Mean post-harvest ratings of Defender, Ranger Russet, and Russet Burbank in full-season trials of the 2000 to 2002 Western Regional Potato Variety Trial.

	Idaho ¹	Oregon	Washington	3-State Mean
Defender	26.3	17.6	17.8	20.1
Ranger Russet	28.8	17.8	19.9	22.2
Russet Burbank	19.5	17.0	21.2	19.2

¹Values were assigned based on the sum of individual ratings for fry color from the field, 8.9 and 6.7 C (60 days storage), reducing sugar concentrations following 60 days storage at 8.9 and 6.7 C, specific gravity, and sensory evaluations by taste panels. Maximum value possible was 38; higher values are indicative of superior post-harvest attributes. Post-harvest evaluations and ratings were conducted at Pullman, WA, using tubers from trials grown at Aberdeen, ID, Hermiston, OR, and Warden/Othello, WA. More detailed information concerning the rating of post-harvest attributes and the calculation of post-harvest ratings for cultivars can be found at: <http://www.wsu.edu/~fullern/methods.htm> and <http://www.potatoes.wsu.edu/trials/postharv-procedures.htm>

TABLE 6—Evaluation of internal and external defects of Defender, Ranger Russet, and Russet Burbank in southern Idaho.

Cultivar	Growth cracks ^{1,3}	Second growth ^{1,3}	Shatter bruise ^{1,4}	Hollow heart ^{2,5}	Blackspot bruise ^{1,5}
Defender	4.5	3.8	2.4	3.4	1.5
Ranger Russet	4.3	4.2	2.7	0.4	1.6
Russet Burbank	3.4	3.1	3.2	6.5	2.2

¹Rated using a 1-5 scale with 1 = severe and 5 = none observed.

²Rated as the percentage of tubers >341 g with hollow heart and brown center

³Average of nine trials

⁴Average of six trials

⁵Average of 21 trials

Potato Variety Trials, Defender again maintained a higher mean specific gravity (1.080) than either Ranger Russet or Shepody (Table 2).

Tuber Defects

Defender had a lower incidence of growth cracks and second growth than Russet Burbank, with values more similar to those of Ranger Russet (Table 6). Defender is more susceptible to shatter bruise than Ranger Russet or Russet Burbank, and intermediate in susceptibility to hollow heart. Defender is susceptible to blackspot bruise, with ratings comparable to that of its blackspot-bruise-susceptible parent, Ranger Russet.

Defender showed a high incidence of tuber internal necrosis (internal brown spot and/or heat necrosis) in 3 years of sequential harvest trials in the southern Columbia Basin at Hermiston, OR (Hane and Leroux 2004). Internal necrosis was <1% in tubers of Defender harvested in early or late August. However, a steady increase in the incidence of internal necrosis from 13% to 18% was noted in tubers of Defender beginning

with trials harvested the first week of September and through the first week of October. The susceptibility of Defender to internal necrosis later in the season is thought to relate in part to the tuber growth habit of Defender. Tubers have a tendency to set high in the hill with an upward slanting (bud end higher than stem end) orientation (Steve Love, personal observation). This orientation and shallow depth expose tubers to higher soil temperatures, thereby promoting internal necrosis as well as tuber greening. Adding 5.0 to 7.6 cm of soil at final hilling to create a "peaked" hill is recommended to reduce the incidence of tuber internal necrosis and greening later in the season. Additionally, harvest date can be adjusted to avoid the onset of late-season internal browning.

Sensory Evaluations

Tubers of Defender are long and white-skinned, limiting its use for fresh-pack markets to production regions such as California that traditionally have grown and marketed long, white-skinned cultivars for early spring and summer fresh

TABLE 7—Sensory evaluations of Defender and Russet Burbank baked potatoes.¹

Cultivar	Early-storage ²				Late-storage ³			
	Color	Texture	Flavor	Overall appeal	Color	Texture	Flavor	Overall appeal
Defender	6.6	6.0	6.0	6.1	6.4	5.7	5.7	5.7
Russet Burbank	6.8	6.3	6.2	6.2	6.6	6.0	5.8	6.0

¹Blind sensory evaluations were conducted in Blackfoot, ID, using 10 to 12 trained panelists. The values given represent the mean of three sessions conducted over a 3-year period from 1999-2001 (one session/year). Tubers were rated for color, texture, flavor, and overall appeal using a scale with 1 = very poor quality and 9 = exceptional quality.

²Early-storage evaluations were conducted approximately 1 month after harvest, prior to the time that the final holding temperature of 4.4 C was reached.

³Late-storage evaluations were conducted following 5 to 6 months storage at 4.4 C.

TABLE 8—Disease responses of Defender, Ranger Russet, Russet Burbank, and Shepody¹.

Cultivar	Vert. wilt	Pink rot ²	Scab		Early Blight		Late Blight		Viruses ³			Symptoms of virus infection		Storage diseases	
			Common	Powdery	Foliar	Tuber	Foliar	Tuber	PLRV	PVY	PVX	Net necrosis	Corky ringspot	Erwinia soft rot	Fus. dry rot
Defender	MR	MR	S	S	MR	R	R	VR	S	MS	VR	R	MR	MR	MS
Ranger Russet	MR	N.A.	S	MR	S	MS	S	VS	S	MR	VR	MR	S	S	MS
Russet Burbank	S	S	MR	MR	S	MS	S	S	S	S	S	S	S	S	S
Shepody	S	N.A.	S	VS	MS	R	VS	MR	S	S	S	MR	S	S	MR

¹Ratings were based on a minimum of 2 years of controlled field evaluations, with the exception of the pink rot evaluation. Ratings are defined as very resistant (VR), resistant (R), moderately resistant (MR), moderately susceptible (MS), susceptible (S), and very susceptible (VS).

²Ratings were based on 1 year of data from tuber inoculations conducted by R.V. James, W. R. Stevenson, and R.E. Rand, Dept. of Plant Pathology, University of Wisconsin-Madison. Report with methodologies can be accessed at:

<http://www.plantpath.wisc.edu/wivegdis/2004%20progress%20reports/wrs413%20potato%20variety%20tubers%202003.pdf>

³Virus reaction was based on seed-born infection as determined by ELISA, following field evaluation with inter-planted virus-infected potato plants and a high population density of green peach aphids.

markets. Taste panel evaluations of baked potatoes support fresh-use of Defender with sensory ratings nearly identical to Russet Burbank in early-storage evaluations, and slightly lower but comparable to Russet Burbank following 5 to 6 months of storage (Table 7).

DISEASE RESPONSE

Defender is notable for its resistance to late blight infection in both foliage and tubers (Table 8, Figures 3 and 4). Progression of late blight in the foliage of Defender is approximately 73% to 75% reduced relative to susceptible cultivars (Figure 3). Late blight resistance of Defender also was evaluated in the Toluca Valley of Mexico, a center of diversity and putative center of origin of *P. infestans*. Foliar resistance was maintained over multiple years of evaluation, indicative of

its durability when challenged with complex pathotypes of *P. infestans* (Dr. Hector Lozoya, unpublished data). Historically, tuber blight has not been expressed to a great degree in the Toluca Valley, thus no observations regarding tuber blight resistance were made. Defender was shown to have tuber resistance to *P. infestans* in field evaluations at Corvallis, OR, as well as following challenge inoculations with sporangia of the US-8 and US-11 genotypes as described by Porter et al. (2004). Defender is classified as very resistant to tuber blight with $\leq 1\%$ external tuber rot (Figure 4). Potato cultivars classified as susceptible to tuber blight averaged 22% to 63% external tuber rot in the same evaluations (Figure 4).

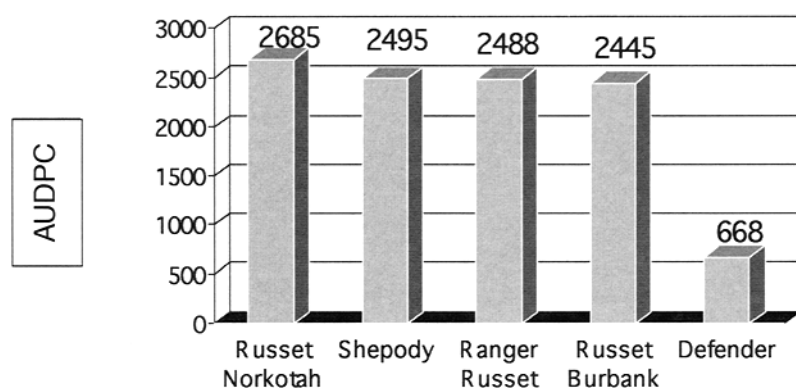


FIGURE 3. Mean area under disease progression curve (AUDPC) for foliar late blight. Defender and susceptible cultivars were evaluated at Mount Vernon, WA, (1996-2000) and Corvallis, OR, (1996-1997). No fungicides were applied in these evaluations.

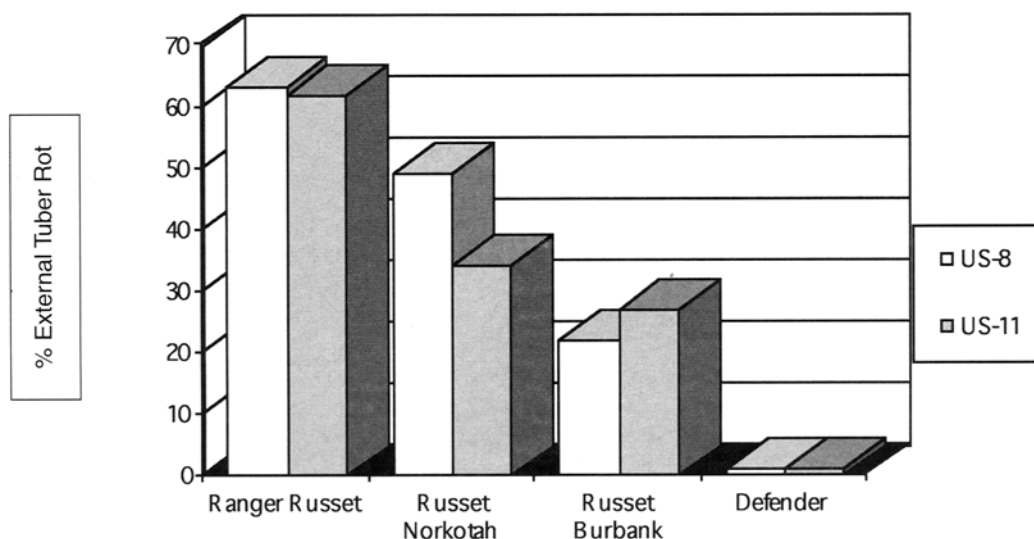


FIGURE 4. Incidence of external tuber rot following single eye inoculations of tubers with sporangia of the US-8 and US-11 genotypes of *P. infestans*. Tuber rot percentages are an average of 6 trials and 4 trials for genotypes US-8 and US-11, respectively (Porter et al. 2004).

Defender also expresses extreme resistance to potato virus X, as well as resistances to net necrosis from potato leafroll virus and tuber infection by early blight (*Alternaria solani*) (Table 8). Defender is less susceptible to foliar early blight, corky ringspot, and *Erwinia* soft rot than Ranger Russet, Russet Burbank, and Shepody. Its resistance to Verticillium wilt (*Verticillium dahliae*) is comparable to that of Ranger Russet and greater than those of Russet Burbank and Shepody. Defender is susceptible to common scab (*Streptomyces scabies* [Thaxter]), powdery scab (*Spongospora subterranea* [Wallr.]), potato leafroll virus, and Columbia root-knot nematode (*Meloidogyne chitwoodi*); it is moderately susceptible to Fusarium dry rot and potato virus Y.

Defender is susceptible to bacterial ring rot (*Clavibacter michiganensis* subsp. *sepedonicus* [Spieck. & Kotth.]), but exhibits a delayed foliar response to bacterial ring rot in comparisons with Russet Burbank and Russet Norkotah. However, foliar expression is obvious within the critical period of seed certification from 90 to 100 days after planting; detection of the presence of bacterial ring rot infection prior to final field inspection for certification is therefore likely. Expression of bacterial ring rot infection in the foliage includes early dwarfing, rosette plant growth, interveinal chlorosis and necrosis, marginal necrosis, and green wilt. Symptoms of bacterial ring rot infection in the tuber are weak to absent (Rob Davidson, unpublished data).

Assignments of disease resistance and susceptibility ratings were based on a minimum of 2 years of replicated field evaluations. Verticillium wilt (*Verticillium dahliae*), common scab, and early blight evaluations were conducted at Aberdeen, ID, using naturally occurring inocula. The protocol for assessing germplasm response to Verticillium wilt was previously described by Corsini et al. (1988). Common scab and early blight evaluations consisted of three replicates in a ran-

domized complete block (RCB) design with analyzed data used for assigning disease reactions. Powdery scab evaluations were conducted over a 2-year period at Parker, Idaho by Dr. Jeff Miller, University of Idaho. Powdery scab trials consisted of three replications in a randomized complete block design with root galling and tuber lesion severity used in assignment of cultivar response. Late blight field evaluations were conducted at Mount Vernon, WA, and Corvallis, OR. Protocols used in the evaluations at Mount Vernon and Corvallis were as described by Inglis et al. (1996) and Mosley et al. (2003). Evaluations of PLRV, PVY, and PVX resistances were conducted at Kimberly, ID, using virus-infected spreader rows as described by Corsini et al. (1994). Corky ringspot evaluations in a RCB design were conducted in the Egin Bench region of Idaho, and the Columbia Basin of Washington and Oregon using protocols described by Brown et al. (2000). Storage disease assessments were as described by Corsini and Pavek (1986). Columbia root-knot nematode ratings were provided by Dr. Chuck Brown, USDA/ARS, on the basis of data from replicated trials conducted in nematode-infected fields of the Columbia Basin of Washington State.

BIOCHEMICAL AND NUTRITIONAL CHARACTERISTICS

Tubers of Defender, Ranger Russet, and Russet Burbank, grown at Aberdeen, ID, were analyzed over a 3-year period to assess biochemical and nutritional components (Table 9). Defender was higher in dry matter content than either Ranger Russet or Russet Burbank, while protein percentages were very similar among the three cultivars. Sucrose levels were higher in Defender than in the check cultivars, while glucose concentrations were comparable to levels observed in Ranger Russet and Russet Burbank. Vitamin C content of Defender

TABLE 9—*Biochemical analyses of Defender, Ranger Russet, and Russet Burbank tubers from the 2000 to 2002 Western Regional Potato Variety Trials at Aberdeen, ID¹.*

Cultivar	Dry matter (%)	Sucrose (% FWB ²)	Glucose (% FWB ²)	Protein (% DWB ²)	Vitamin C (mg/100g FWB ²)	Total glycoalkaloids (mg/100g FWB ²)
Defender	24.3	0.26	0.11	5.5	33.0	6.8
Ranger Russet	23.0	0.21	0.10	5.4	31.9	5.6
Russet Burbank	20.8	0.17	0.09	5.2	19.5	4.2

¹Analyses were conducted on freeze-dried tuber tissue at Aberdeen, ID; tissue was taken from tubers 6 weeks after harvest.

²FWB = fresh weight basis; DWB = dry weight basis.

was greater than both check cultivars; this observation is notable in that Ranger Russet has been identified as a cultivar exceptionally high in vitamin C (Love et al. 2004). Therefore, Defender also may be categorized as a high vitamin C cultivar. Total glycoalkaloids for Defender were slightly higher than levels observed in the check cultivars, but were nonetheless far below the critical threshold of 20 mg/100g tuber fresh weight.

MANAGEMENT

Studies on management practices optimal for production of Defender were conducted primarily in southeastern Idaho. Results of these studies also may provide growers in other production regions with a foundation for the development of management guidelines specific for their locale.

Seed spacing trials indicate that the optimal commercial spacing of Defender seedpieces on 91 cm rows is 25.4 to 30.5 cm. Seed should be planted 12.8 to 17.8 cm deep with 5.0 to 7.7 cm of soil applied at final hilling to minimize tuber greening.

Nitrogen management recommendations were developed based on an experimental trial, combined with predictions based on growth habit; recommendations were validated in their successful adoption in commercial production. Total nitrogen application recommendations for Defender are approximately 80% to 100% of recommendations for Russet Burbank. In eastern and central Idaho, it is recommended that 224 to 280 kg N/ha (200 to 250 lbs N/acre) be applied, with soil residual nitrogen to be included in the aforementioned recommended rates. One-third to one-half of the recommended nitrogen may be applied at planting, with the remainder applied prior to August 10th. Nitrogen applied after the August deadline will delay maturity of this cultivar, creating difficulties with vine kill, tuber maturation, and subsequent storage. Critical petiole nitrate levels for Defender have not been established.

No detailed research has been conducted regarding the phosphorus, potassium, or micronutrient requirements of Defender. Until such recommendations are developed, it is recommended that growers follow nutrient guidelines developed for Russet Burbank in their growing region.

It is recommended that available soil moisture for Defender be maintained in the range of 65% to 80% throughout the growing season. Based on observations that Defender maintains a green, vigorous vine longer than Russet Burbank in full-season trials, it is likely that more water will be needed rel-

ative to Russet Burbank prior to harvest. Avoid severe soil drying during vine killing of Defender. Low soil moisture can result in tuber dehydration thereby exacerbating blackspot bruise.

Defender is similar to Ranger Russet with respect to bruise and sugar accumulation issues in storage. Therefore, the following management recommendations for Ranger Russet (Love et al., 2003) are pertinent to Defender: (1) minimize the incidence of blackspot bruise by maintaining green vines up to vine kill or by "green digging", i.e., harvesting directly from the field without vine kill, (2) avoid tuber chilling in the ground prior to harvest, and (3) store harvested tubers at 9.0 C-a temperature that has been validated through storage evaluations as optimal for Defender for the production of fries following long-term storage (Kleinkopf et al. 2005).

Defender has not been observed as being sensitive to metribuzin when applied at labeled rates. The critical period for weed control in Defender is prior to row closure. Defender produces a vine that competes well with most mid- to late-season weeds.

SEED AVAILABILITY

In 2005, seed was available from potato seed growers in Idaho, Montana, Oregon, and Washington. Small amounts of seed, for research purposes, can be obtained by contacting the corresponding author. The University of Idaho, acting on behalf of the Northwest (Tri-State) Potato Variety Development Program, has filed an application for Plant Variety Protection for Defender.

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